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An Image processing method for extraction of regions in MRI
- Muscle metabolism in the human forearm -

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INTRODUCTION

For the quantitative evaluation of metabolic changes in the biological tissue by MRI (Magnetic Resonance Imaging), some characteristics in the MR image should be detected. The characteristics are, for example, image intensity and geometrical changes caused by the biological metabolism. This paper proposes an image processing method for the detection of metabolic changed or activated regions. In this method, these regions are detected by the center of gravity of some characteristics regions and then the region is recognized by the region growing. These regions are detected correctly even if the human body is moved.

MR IMAGING

The Nuclear Magnetic Resonance (NMR) is able to imaged some values - the spin density (SD), relaxation times (T1, T2 and T2*), the self diffusion coefficient (D) and chemical shift (δ), and their spatial distribution and time changes. The metabolic changes are detected by the blood flow, perfusion and chemical changes imaged by D, T2* and δ. These values are strongly depending on the biological metabolism. To detect the metabolic changes in the human forearm, two MRI methods, the gradient recalled echo (GRE) for T2* imaging and the spin echo diffusion (SE-DWI) for D imaging is used.

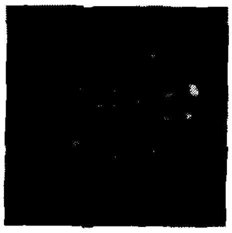


Fig 1 : An MR image of the human fore-arm
Gradient Echo method, (TR=118msec, TE=20msec,
Flip angle=20 degrees, Matrix =128 by 128 pixels)

Figure 1 shows an example of two-dimensional T2*-weighted image of the human forearm (healthy volunteer, left forearm) by the GRE method. Some muscles, blood vessels and two bones and the fat just under the skin are observed, and those are the useful geometrical characteristics for the classification of tissues. In the T2*-weighted imaging with different TE

(20, 40 and 60 msec), oxygen concentration and the effect of blood flow. On the other hand, the diffusion weighted imaging with different B values is evaluated for perfusion and/or microcirculation in the tissue. This paper describes an experimental result for the muscle fatigue of human forearm as follows. Two experiments had been done for the muscle fatigue before and after MR imaging with the hand griped tightly in one minute. These images, in this paper, are named the control-image and the fatigue-image before and after fatigued, respectively. Four sliced images, 10 mm slice gap, are acquired and reconstructed in both imaging (T2* and D).

IMAGE PROCESSING

To extract features in the MR images acquired and reconstructed images before and after metabolic changes by fatigued, following image processing had been done -

(I) For the control-image,

(1) to reduce the noise by the median filter.

(2) to classify of every regions where have different intensity distribution and labeling.

(3) to automatically find out the center of gravity of two bones, Radius and Ulna, respectively – point A and B in the Fig2.

(4) to put a point C at any location in a region for the target muscle on the image as shown in Fig.2. Where, the target muscle means that a muscle, which is evaluated the biological metabolism and the point C is able to put anywhere in the muscle region.

(5) to calculate the geometrical relationship (the distance and the orientation) among these 3 points, A, B and C.

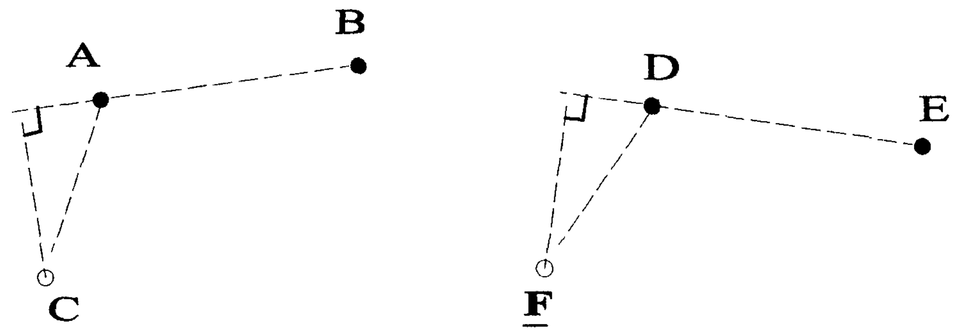


Fig.2 geometrical relation among three points A, B and C, and D, E and F.

(a) Three points designated in the control-image as the center of gravity and a point in the target muscle. (b) Three points calculated automatically and assumed in the fatigue-image. The Point A, D : the center of gravity for the Radius, the Point B, E : the center of gravity for the Ulna

(II) For the fatigue-image,

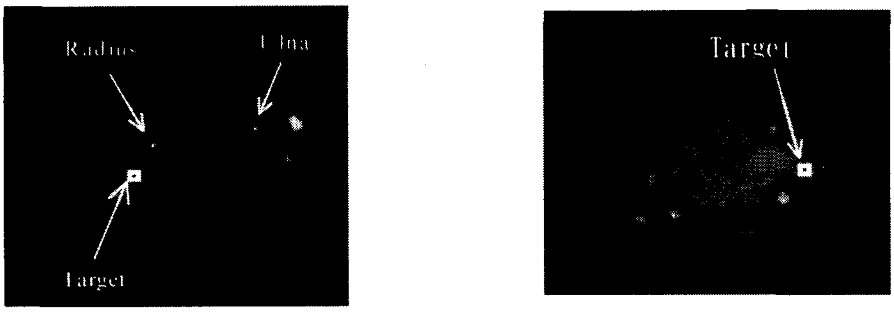
(1) to automatically find out the center of gravity of two bones – point D and E in the Fig3.

(2) to calculate a point F in accordance with of the geometrical relationship in Fig3, and assumed as same location as the point C.

(3) to enlarge the region surrounding the point F, and extract and detect the region of the target muscle.

RESULTS

Figure 3 shows an experimental result of detection of the target muscle. Extracted points are shown in these images. Proposed method is able to detect the target muscle correctly even if the image is moved and/or rotated. Figure 4 shows image intensity corresponding individual regions extracted as the target muscle in the two images, control-image and fatigue-image. The neighborhood, in the horizontal axis, means that the regions size around an extracted point F in the target muscle as shown in Fig.2. The target region is increased when the number of neighborhood is increased. The maximum number of the neighborhood is reached to the edge of the target muscle. The mean value, in the vertical axis, is normalized by the maximum intensity of the two images, the control- and the fatigue-image. The mean value of the image intensity at the region is clearly increased when the muscle is fatigued.



(a) a control image (b) a fatigue-image

Fig.3 An experimental results of detection of fatigued muscle.
In this example, the fatigue-image is geometrically rotated.

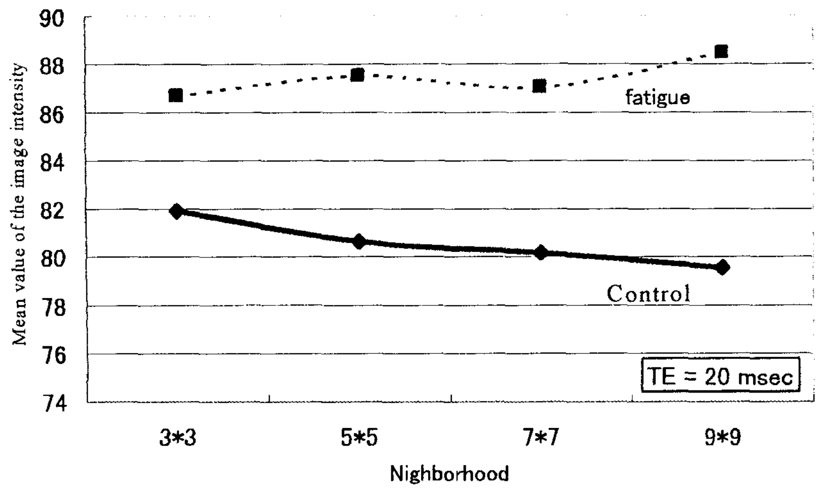


Fig.4 Image intensity of the extracted muscle before and after fatigued.

CONCLUSION

This paper described an image processing method for the detection of metabolic changed and activated regions. This method is to detect corresponding regions between in MR images before and after applying physical stress such as the fatigue. From the processing results, this method is able to evaluate even if the image is moved and/or rotated, and is applied to the functional MRI for the brain metabolism. In the GRE imaging, acquired gradient echo is very sensitive inhomogeneity of magnetic field. In some reconstructed images, some artifacts such as irregular intensity distribution and unexpected shadows are appeared. Some image processing techniques such as the adaptive image processing should be used.